

2. RECONNAISSANCE AND FIXES

2.1 GENERAL

JTWC depends primarily on two reconnaissance platforms, satellite and radar, to provide necessary, accurate and timely meteorological information in support of advisories, alerts and warnings. When available, synoptic and aircraft reconnaissance data are also used to supplement the above. As in past years, the optimal use of all available reconnaissance resources to support JTWC's products remains a primary concern. Weighing the specific capabilities and limitations of each reconnaissance platform, and the tropical cyclone's threat to life and property, both afloat and ashore, continues to be an important factor in careful product preparation.

2.2 RECONNAISSANCE AVAILABILITY

2.2.1 SATELLITE — Interpretation of satellite imagery by analysts at Air Force/Navy ground sites and on Navy ships yields tropical cyclone positions, estimates of the current intensity, and 24-hr forecast intensity. Additional positioning and surface wind estimation information are available for analysis where DMSP SSM/I and ERS-1 scatterometer are received and displayed.

2.2.2 RADAR — Interpretation of land-based radar, which remotely senses and maps precipitation within tropical cyclones, provides positions in the proximity (usually within 175 nm (325 km) of radar sites in the Kwajalein, Guam, Japan, South Korea, China, Taiwan, Philippine Islands, Hong Kong, Thailand, India and Australia. Where Doppler radars are located, such as the WSR-88D on Guam, measurements of radial velocity are also available, and observations of the tropical cyclone's horizontal velocity field and wind structure integrated in the vertical are possible within the radar volume.

2.2.3 AIRCRAFT — No weather reconnaissance aircraft fixes were received at JTWC in 1995.

2.2.4 SYNOPTIC — JTWC also determines tropical cyclone positions based on the analysis of conventional surface/gradient-level synoptic data. These positions are an important supplement to fixes provided by analysts using data from remote sensing platforms, and become most valuable in situations where neither satellite, radar, nor aircraft fixes are available or representative.

2.3 SATELLITE RECONNAISSANCE SUMMARY

The Air Force provides satellite reconnaissance support to JTWC through the DMSP Tropical Cyclone Reporting Network (DMSP Network), which consists of several tactical sites and a centralized facility. The personnel of the Satellite Operations (hereafter referred to as Sat Ops) at 36 OSS/OSJ, collocated with JTWC at Nimitz Hill, Guam, coordinate required tropical cyclone reconnaissance support with the following units:

<u>Unit</u>	<u>Call sign</u>
15 OSS/OSW, Hickam AFB, Hawaii	PHIK
18 OSS/OSW, Kadena AB, Japan	RODN
607 COS/DOW, Osan AB, Republic of Korea	RKWU
Air Force Global Weather Central, Offutt AFB, Nebraska	KGWC
NPMOD DGAR, Diego Garcia	FJDG

The DMSP Network sites provide a combined coverage from polar orbiting satellites that includes most of the western North Pacific, from near the international date line westward into the South China Sea. The Naval Pacific Meteorology and Oceanography Detachment at Diego Garcia furnishes fixes through interpretation of high resolution NOAA and DMSP polar

orbiting satellite imagery that covers the central Indian Ocean, and Navy ships equipped for direct satellite readout contribute supplementary support. Also, civilian contractors with the U.S. Army at Kwajalein Atoll supplement Sat Ops satellite coverage with fixes on tropical cyclones in the Marshall Islands and east of the date line.

Additionally, mosaics developed from DMSP satellite imagery are available from the AFGWC via AWDS. These mosaics are used to metwatch the areas not included in the coverage of DMSP Network tactical sites. They provide JTWC forecasters with the time-delayed capability to "see" what AFGWC's satellite image analysts have been fixing. Also available are three-hourly METEOSAT-5 infrared images from NEMOC via JTWC'S M1000, allowing forecasters to animate these regions.

Sat Ops also uses high resolution geostationary imagery to support the reconnaissance mission. Animation of images is invaluable for determining the location and motion of cloud system centers, particularly in the formative stages. Animation is also valuable in assessing changes in the environment that affect tropical cyclone behavior. Sat Ops is able to process high resolution digital geostationary data through its MIDDAS, and the Navy's Geostationary Satellite Receiving System (GSRS). The MIDDAS consists of a network of three microcomputers, advanced graphics software, and large screen work stations that process and display geostationary imagery, NOAA High Resolution Picture Transmission (HRPT) and TIROS Operational Vertical Sounder (TOVS) data, and DMSP imagery.

In support of JTWC, AFGWC analyzes stored imagery from both the DMSP and NOAA spacecraft. These imagery are recorded and stored onboard the spacecraft for later relay to a command readout site which in turn passes the data via a communication satellite to AFGWC. This enables AFGWC to obtain the global coverage needed to monitor all tropical cyclones worldwide several times a day.

The hub of the DMSP Network is Sat Ops, which is responsible for coordinating satellite reconnaissance requirements with JTWC and tasking the individual network sites for the necessary tropical cyclone fixes, current intensity estimates, and SSM/I-derived surface winds. Sat Ops monitors all suspect areas defined by the JTWC using geostationary METSAT data. When a warning is in effect, two sites will be tasked if possible for all passes falling within the "warning window" of 1 hour prior to and 1.5 hours after warning time. It also supplies independent assessments of the same data to provide TDOs a measure of confidence in the location and intensity information.

The DMSP Network provides JTWC with several products and services. The main service is to monitor the AOR for indications of tropical cyclone development. If development is suspected, JTWC is notified. Once JTWC issues either a TCFA or a warning, the DMSP Network provides tropical cyclone positions and current intensity estimates, with a forecast intensity estimate implied from the code (Dvorak 1975, 1984) shown in Figure 2-1. Each satellite-derived tropical cyclone position is assigned a Position Code Number (PCN), which is a measure of positioning confidence. The PCN is determined by a combination of 1) the availability of visible landmarks in the image that can be used as references for precise gridding, and 2) the degree of organization of the tropical cyclone's cloud system (Table 2-1). Once the tropical cyclone's intensity reaches 50 kt (26 m/sec), the DMSP Network analyzes the distribution of SSM/I-derived 35-kt (18-m/sec) winds in the rain-free areas near the tropical cyclone.

Sat Ops provides at least one estimate of the tropical cyclone's current intensity every 6 hours once JTWC is in alert or warning status. Current intensity estimates are made using the Dvorak technique for both visible and enhanced infrared imagery. For the intensity analysis of mature tropical cyclones, the enhanced infrared

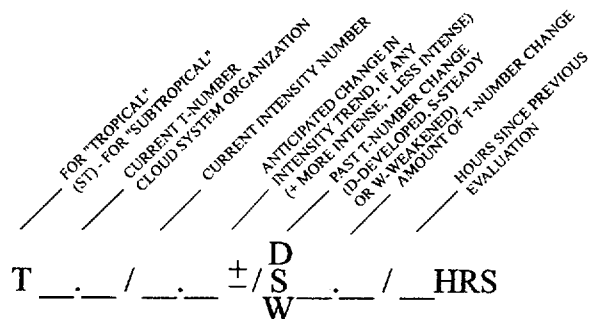


Figure 2-1 Dvorak code for communicating estimates of current and forecast intensity derived from satellite data. In the example, the current "T-number" is 3.5, but the current intensity is 4.5. The cloud system has weakened by 1.5 "T-numbers" since the evaluation conducted 24 hours earlier. The plus (+) symbol indicates an expected reversal of the weakening trend or very little further weakening of the tropical cyclone during the next 24-hour period.

technique is preferred due to its objectivity; however, daily use of the visible technique adds a measure of consistency and helps resolve ambiguities in the enhanced infrared techniques. The standard relationship between tropical cyclone "T-number", maximum sustained surface wind speed, and minimum sea-level pressure (Atkinson and Holliday, 1977) for the Pacific is shown in Table 2-2. For subtropical cyclones, intensity estimates are made using the Hebert and Poteat (1975) technique.

Table 2-1 POSITION CODE NUMBER (PCN)

PCN	METHOD FOR CENTER DETERMINATION/GRIDDING
1	EYE/GEOGRAPHY
2	EYE/EPHEMERIS
3	WELL DEFINED CIRCULATION CENTER/GEOGRAPHY
4	WELL DEFINED CIRCULATION CENTER/EPHEMERIS
5	POORLY DEFINED CIRCULATION CENTER/GEOGRAPHY
6	POORLY DEFINED CIRCULATION CENTER/EPHEMERIS

2.3.1 SATELLITE PLATFORM SUMMARY—Figure 2-2 shows the operational status of polar orbiting spacecraft. Data were received from four DMSP spacecraft during 1995. Of these, F10 and F11 provided only SSM/I imagery.

F12 produced only Operational Line Scan (OLS). F13 was launched in Mar of 1995 and became fully operational in May. F8 remained in standby mode. Of the TIROS-N spacecraft, NOAA 12 was fully operational. NOAA-14

Table 2-2 ESTIMATED MAXIMUM SUSTAINED WIND SPEED (KT) AS A FUNCTION OF DVORAK CURRENT AND FORECAST INTENSITY NUMBER AND MINIMUM SEA-LEVEL PRESSURE (MSLP)

T-NUMBER	ESTIMATED WIND SPEED-KT (M/SEC)	MSLP (MB) (PACIFIC)
0.0	<25 (<13)	- - - -
0.5	25 (13)	- - - -
1.0	25 (13)	- - - -
1.5	25 (13)	- - - -
2.0	30 (15)	1000
2.5	35 (18)	997
3.0	45 (23)	991
3.5	55 (28)	984
4.0	65 (33)	976
4.5	77 (40)	966
5.0	90 (46)	954
5.5	102 (53)	941
6.0	115 (59)	927
6.5	127 (65)	914
7.0	140 (72)	898
7.5	155 (80)	879
8.0	170 (87)	858

was launched in December 1994 and became operational in April, 1995. NOAA-10 was deactivated in March and NOAA-11 failed in April. NOAA-9 remained in standby mode.

2.3.2 STATISTICAL SUMMARY —During 1995, fix and intensity information from the DMSP Network was the primary input to JTWC's warnings and postanalyses. JTWC received at least 7949 satellite fixes — 4802 covered tropical cyclones in the western North Pacific, 367 in the North Indian Ocean, and 1813 in the Southern Hemisphere. The geostationary platform was the source of 65 percent of the fixes and 35 percent were from polar orbiters. A comparison of all satellite fixes with only their corresponding best track positions is shown in Table 2-3.

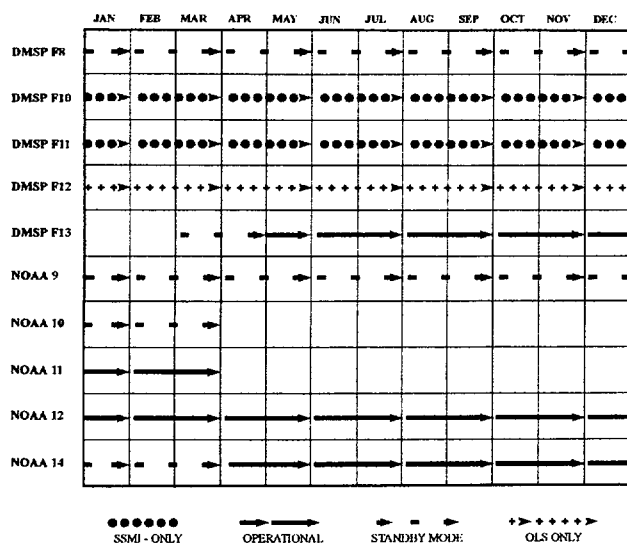


Figure 2-2 Polar orbiting spacecraft status for 1995

2.3.3 APPLICATION OF NEW TECHNOLOGY — Sat Ops continued to make use of the real-time direct transmissions of SSM/I data received, processed and displayed by the Air Force's Mark IVB tactical terminals for surface wind speed estimation. These data were routinely used to identify areas of 35-kt winds, particularly surrounding tropical cyclones. Time-late SSM/I data, stored on board the DMSP spacecraft for later reception, processing and forwarding from FNMOC to be displayed on the MISTIC II, provided coverage over the JTWC's entire AOR. These time-late SSM/I data were used by analysts at AFGWC to develop 35-kt wind envelope bulletins for tropical cyclone warning support.

2.3.4 FUTURE OF SATELLITE RECONNAISSANCE — Sat Ops remains committed to improving support to the PACOM tropical cyclone warning system. The most significant improvement planned in 1996 is the availability of data from more satellite platforms. AFGWC is planning a new capability to include the use of data from more Geostationary satellites in providing fix support. This capability allows for better metwatch and fix support over the

entire JTWC AOR. Internal projects include the verification of SSM/I data related to position estimates of tropical cyclones in a highly sheared environment.

2.4 RADAR RECONNAISSANCE SUMMARY

Of the 34 significant tropical cyclones in the western North Pacific during 1995, 12 passed within range of land-based radar with sufficient precipitation and organization to be fixed. A total of 292 land-based radar fixes were logged at JTWC. As defined by the World Meteorological Organization (WMO), the accuracy of these fixes falls within three categories: good [within 10 km (5 nm)], fair [within 10 - 30 km (5 - 16 nm)], and poor [within 30 - 50 km (16 - 27 nm)]. Of the 264 radar fixes encoded in this manner, 62 were good, 138 fair, and 92 poor. The radar network provided timely and accurate fixes which allowed JTWC to better track and forecast tropical cyclone movement. In addition to fixes, the Andersen AFB (Guam) WSR-88D radar supplied meteorologists with a look into the vertical and horizontal structure of precipitation and winds in tropical cyclones passing near the island.

In the Southern Hemisphere, two radar reports were logged for tropical cyclones. No radar fixes were received for the North Indian Ocean.

2.5 TROPICAL CYCLONE FIX DATA

Table 2-4a delineates the number of fixes per platform for each individual tropical cyclone for the western North Pacific. Totals and percentages are also indicated. Similar information is provided for the North Indian Ocean in Table 2-4b, and for the South Pacific and South Indian Ocean in Table 2-4a.

Table 2-3 MEAN DEVIATION(NM) OF ALL DMSP NETWORK DERIVED
TROPICAL CYCLONE POSITIONS FROM JTWC BEST TRACK POSITIONS
(NUMBER OF CASES IN PARENTHESES)

NORTHWEST PACIFIC OCEAN				
<u>PCN</u>	<u>1985-1994 AVERAGE</u>		<u>1995 AVERAGE</u>	
1&2	14.0	(6980)	14.5	(561)
3&4	23.1	(6604)	27.4	(601)
5&6	39.5	(16253)	50.8	(1823)
Totals	29.9	(29837)	39.3	(2985)

NORTH INDIAN OCEAN				
<u>PCN</u>	<u>1985-1994 AVERAGE</u>		<u>1995 AVERAGE</u>	
1&2	12.5	(149)	15.8	(15)
3&4	32.4	(130)	24.9	(31)
5&6	38.5	(1348)	37.3	(162)
Totals	35.6	(1627)	33.9	(208)

WESTERN SOUTH PACIFIC AND SOUTH INDIAN OCEAN				
<u>PCN</u>	<u>1985-1994 AVERAGE</u>		<u>1995 AVERAGE</u>	
1&2	15.7	(2521)	15.5	(181)
3&4	26.2	(2104)	25.9	(132)
5&6	39.7	(9273)	33.7	(712)
Totals	33.3	(13898)	29.4	(1025)

Table 2-4a

1995 NORTHWEST PACIFIC OCEAN FIX PLATFORM SUMMARY

<u>TROPICAL CYCLONE</u>	<u>SATELLITE</u>	<u>RADAR</u>	<u>SYNOPTIC</u>	<u>AIRCRAFT</u>	<u>TOTAL</u>
01W TD	24	0	0	0	24
02W TS CHUCK	77	0	0	0	77
03W TS DEANNA	135	0	4	0	139
04W TS ELI	74	1	0	0	75
05W TY FAYE	204	65	6	0	275
06W TS UNNAMED	54	0	2	0	56
07W TY GARY	55	25	3	0	83
08W TY HELEN	109	13	13	0	135
09W TS IRVING	47	11	0	0	58
10W TS JANIS	113	0	12	0	125
11W TD	8	0	0	0	8
12W STY KENT	106	8	0	0	114
13W TY LOIS	85	0	0	0	85
14W TY MARK	44	0	0	0	44
15W TS NINA	78	0	5	0	83
16W TD	21	0	0	0	21
17W STY OSCAR	112	22	0	0	134
18W TY POLLY	169	0	0	0	169
19W STY RYAN	155	86	1	0	242
20W TY SIBYL	119	14	13	0	146
21W TD	45	0	0	0	45
22W TD	38	0	0	0	38
23W TD	23	0	0	0	23
24W TY TED	76	0	0	0	76
25W TS VAL	85	0	2	0	87
26W STY WARD	156	20	0	0	176
27W TY YVETTE	76	0	0	0	76
28W TY ZACK	162	5	7	0	174
29W STY ANGELA	234	10	0	0	244
30W TS BRIAN	51	0	1	0	52
31W TS COLLEEN	33	0	0	0	33
32W* TD	41	2	0	0	43
34W TD	61	0	0	0	61
35W TS DAN	102	0	1	0	103
Totals	2972	282	70	0	3324
Percentage of Total	89%	9%	2%	0%	100%

* Regenerated

Table 2-4b

1995 NORTH INDIAN OCEAN FIX PLATFORM SUMMARY

<u>TROPICAL CYCLONE</u>	<u>SATELLITE</u>	<u>RADAR</u>	<u>SYNOPTIC</u>	<u>AIRCRAFT</u>	<u>TOTAL</u>
01B	39	0	1	0	40
02A	40	0	0	0	40
03B	55	0	1	0	56
04B	79	0	1	0	80
Totals	213	0	3	0	216
Percentage of Total	99%	0%	1%	0%	100%

Table 2-4c1995 SOUTH PACIFIC AND SOUTH INDIAN OCEANS
FIX PLATFORM SUMMARY

<u>TROPICAL CYCLONE</u>	<u>SATELLITE</u>	<u>RADAR</u>	<u>SYNOPTIC</u>	<u>AIRCRAFT</u>	<u>TOTAL</u>
01P Vania	78	0	0	0	78
02S Albertine	73	0	0	0	73
03S Annette	70	0	0	0	70
04P ----	13	0	0	0	13
05P William	14	0	0	0	14
06S Benthia	24	0	0	0	24
07S Christelle	22	0	2	0	24
08S Dorina	82	0	0	0	82
09S Fodah	18	0	0	0	18
10S Gail	44	0	0	0	44
11S Heida	55	0	0	0	55
12S Bobby	71	0	0	0	71
13S Ingrid	38	0	2	0	40
14P Violet	46	0	0	0	46
15P Warren	29	2	0	0	31
16S Josta	28	0	0	0	28
17S Kylie	51	0	2	0	53
18P ----	5	0	0	0	5
19S Marlene	102	0	0	0	102
20S ----	33	0	0	0	33
21S Chloe	63	0	0	0	63
22P Agnes	86	0	0	0	86
Totals	1045	2	6	0	1053
Percentage of Total	99%	<1%	<1%	0%	100%

Intentionally left blank